WEAVING *FABRICA* AND *RATIOCINATIO*: An Inquiry into the Knowledge of Architecture in Vitruvian Theory

Hayri Dortdivanlioglu
Georgia Institute of Technology

Abstract: This study focuses on *fabrica* and *ratiocinatio*, two fundamental components of architecture, forming the foundational framework of Vitruvian theory. Despite their significance, the Vitruvian text neither gives clear definitions of these terms nor explains their role in architecture. The extensive literature on *fabrica* and *ratiocinatio* has produced various interpretations based on the doctrine of duality between the two concepts. Scholars view *fabrica* as the activity of performing a craft, while they interpret *ratiocinatio* as reasoning and argumentation in rhetoric. Their comparison between *fabrica* and *ratiocinatio* reveals a fundamental distinction where the former is the activity of manual labor, and the latter is the activity of intellectual labor. This distinction becomes significant for Vitruvian literature to the extent that they define both concepts in oppositions of practice versus theory.

Building upon the existing literature, this study questions the relationship between *fabrica* and *ratiocinatio* in the Vitruvian theory of architecture. Rather than focusing on the opposition between the two Vitruvian concepts, it seeks interactions between *fabrica* and *ratiocinatio*. To that end, this study not only offers a close reading of Vitruvian passages but also analyzes the etymology and use of these two concepts in other fields, including *technē* and rhetoric, from which *fabrica* and *ratiocinatio* have originated. It argues that while the origins of these concepts are opposed to each other as concerning purely practical and theoretical activities of architects, this paper shows that Vitruvius redefines them within his architectural theory. First, Vitruvius defines *fabrica* with *meditatio* to show that it is not only a manual but also a mental activity. Secondly, he extends the use of *ratiocinatio* from rhetoric into architecture by defining it as an activity that provides persuasion and coherence in work through both demonstrating and making. By doing so, Vitruvius sets *fabric*a and *ratiocinatio* in action together. They work interdependently. In the last part, this study will examine how *fabrica* and *ratiocinatio* interact with each other and work in and through drawing which is an activity of both hands and mind.

Keywords: Vitruvius, architectural theory, *fabrica, ratiocinatio*, interwoven, drawing

INTRODUCTION

Vitruvius starts his famous treatise, *De Architectura*, by stating that the knowledge of architecture, which is "equipped with many branches of study and varied kinds of learning"[1], is born from *fabrica* and *ratiocinatio* (1.1.1). These two concepts form the foundational framework of Vitruvius's theory of architecture. Understanding the role of *fabrica* and *ratiocinatio* in architect's knowledge is therefore a key to unfolding the body of Vitruvian theory. This essay focusing on the interaction between *fabrica* and *ratiocinatio* is an initial study of broader research on the relationship between three main conceptual frameworks of Vitruvius's theory of architecture. *Fabrica* and *ratiocinatio* form the first framework of his definition of architecture (1.1.1). The second framework is his six principles of design: *ordinatio, dispositio, eurythmia, symmetria, decor*, and *distributio* (1.2.1). The third framework is his famous triadic structure of *firmitas, utilitas,* and *venustas* (1.3.2). Vitruvius's six principles interact under *fabrica* and *ratiocinatio*, and they lead the architecture towards his triadic structure. In the eighteenth century, Berardo Galiani (1758), who produced an Italian translation of *De Architectura* with an extensive commentary, illustrated that *fabbricazione* (building), one of the three main components of the architecture, derives from both part of *fabrica* and *ratiocinatio* for which he uses *pratica* (practice) and *teorica* (theory) respectively (figure 1).[2] Galiani's diagram shows that both *fabrica* and *ratiocinatio* are linked to a network of Vitruvian principles. The diagram's network structure shows that Galiani implies reciprocity between these two concepts, but how do they work together? What is the role of *fabrica* and *ratiocinatio* in Vitruvian theory?

Despite their significance, the meaning of *fabrica* and *ratiocinatio* remains obscure for modern readers due to their textual and semantic problems. The promise of solving these problems resulted in a rich literature including numerous translations with heavy commentaries and literary studies on the meaning and role of *fabrica* and *ratiocinatio* in architecture, specifically in Vitruvian theory. These studies vary in approach, scope, and focus, but they mostly consider

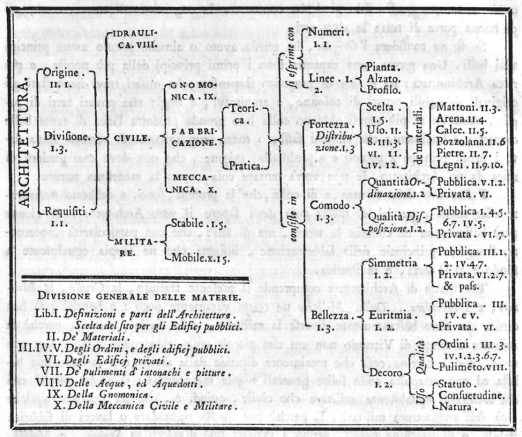

Figure 1: Galiani's diagram of Vitruvian concepts. (Galiani 1758, xv)

fabrica and *ratiocinatio* in a duality of practice versus theory. One group of scholars, including Daniel Barbaro (1584), Carl Watzinger (1909), Louis Callebat (2001), Edmond Frezouls (1985, 1989), and Pierre Gros (2006), considers *fabrica* as work (*opus*) and *ratiocinatio* as the reflection, or discussion on the work carried out, i.e., *ratiocinatio* always comes after the work is completed. Focusing on *ratiocinatio* as a term originated in rhetoric, they link Vitruvian pair to another obscure rhetorical pair of *significatur* (work) and *significat* (explanation), which Vitruvius discusses next in the same chapter. According to Frezouls (1985), *ratiocinatio* is the intellectual activity that analyzes the technical achievement of *fabrica*. He claims that lack of *ratiocinatio* does not prevent architects from building well but from obtaining the authority through a reasoned explanation. Likewise, Watzinger asserts architects must not only build, but also make judgments about their buildings; they must not only be practical but also theoretically educated (1909, 203). While Watzinger suggests a balance between *fabrica* and *ratiocinatio*, Barbaro (1584) and Gros (2006) argue that Vitruvius privileges latter over former. Barbaro claims that judging a work is the differentiating quality (*differentia specifica*) of architects (Williams, 2019, xvii).[3]

On the other hand, another group of scholars, including Claude Perrault (1673, 1674), Galiani (1758), and Jolles (1905), considers *fabrica* as practical knowledge and *ratiocinatio* as theoretical knowledge. Galiani explains that the theory consists of knowing how to conceive the best distribution of a given space to form it with the most convenient materials. The practice then consists of knowing how to implement the already conceived idea in work (1758, xvi). Claiming that theory is the basis of practice, this group of scholars considers that *ratiocinatio* precedes *fabrica* in Vitruvian theory. To highlight this order, in his well-received abridgment, Perrault explains *ratiocinatio* before *fabrica*, even though in the original text the former appears before the latter (Perrault, 1674). In the English edition of his abridgement, he writes, "[t]he theory of architecture is that knowledge of this art which is acquired by study, travelling and discourse. The practice is that knowledge that is acquired by the actual building of great fabricks" (Perrault 1692, 24). Similar to Perrault's view, Jolles (1905) considers *fabrica* as knowledge of the technique of craft and *ratiocinatio* as theoretical knowledge. Thus, a duality between *fabrica* and *ratiocinatio* dominates the interpretations of Vitruvian concepts.

This duality can also be observed in classical Greek philosophy associated with Vitruvius's *fabrica* and *ratiocinatio* (Frezouls 1989, 41). Scholars point out indeed that the Vitruvian pair of *fabrica* and *ratiocinatio* recalls classical Greek oppositions, such as the one between *technē* (craft, skill) and *epistēmē* (knowledge)[4], or Aristotelian *ergon* (work) and *logos* (reason)[5], or Plato's distinction of science as *praktikē* (the science of action) and *gnostikē* (the science of mere knowing)[6]. Furthermore, this duality appears in the fields that *fabrica* and *ratiocinatio* stem from, i.e., respectively, craft and rhetoric. Since Vitruvius writes *De Architectura* on the cusp of emerging Latin language in the early Roman Empire, there were not many Latin texts produced on art and architectural criticism in his time (Fitzpatrick 2017, 4). Consequently, Vitruvius adapts most of his concepts, including *fabrica* and *ratiocinatio*, from Greek and early Roman sources into his architectural theory (Fitzpatrick 2017; Rowland 2005). Vitruvius borrows *fabrica* from craft and *ratiocinatio* from rhetoric, thereby continuing the established duality. Indeed, ancient Greeks saw craft as a form of low art based on mere practice whereas they viewed rhetoric as an intellectual endeavor, which is part of the liberal arts (Masterson 2004). Even though *fabrica* and *ratiocinatio* are related to these classical Greek concepts, none of them, in fact, corresponds precisely to Vitruvian definitions for he redefines them within his architectural theory.

Building upon the existing literature, this study reconsiders the prevalent duality between *fabrica* and *ratiocinatio*. It seeks interactions between *fabrica* and *ratiocinatio* in Vitruvian theory to weave their threads into each other. While it seems as though, at first, this inquiry uses weaving as a metaphor to illustrate the relationship between *fabrica* and *ratiocinatio*, the act of weaving, in fact, goes beyond a metaphor.[7] This inquiry initiates a discussion of creating a network among the pairs of fabric/loom, matter/design, and *fabrica/ratiocinatio*. The first part will analyze the earlier uses of *fabrica* and *ratiocinatio* in ancient Greek and early Roman literature to show the similarities

and differences between the terms' origins and their definitions by Vitruvius. Then, through a close reading of Vitruvian text, it will analyze Vitruvius's redefinition of these terms based on his agenda of writing an architectural treatise, i.e., elevating architecture to the status of a liberal art. These analyses show that *fabrica* and *ratiocinatio* are not symmetrically different. This study claims that Vitruvius's contribution to these concepts put *fabrica* and *ratiocinatio* in interaction with each other. As an alternative to the doctrine of duality between the Vitruvian pair, this inquiry considers *fabrica* and *ratiocinatio* in an interwoven relationship. It argues that *fabrica* involves intellectual activity as much as *ratiocinatio* involves manual activity. While *fabrica* works in the matter, it reckons the form, and, simultaneously, while *ratiocinatio* calculates, it reckons the matter. To illustrate how they perform in matter, this study will analyze drawing in Vitruvian theory as both a product and an activity of architects.

1. VITRUVIUS'S REDEFINITION OF *FABRICA* AND *RATIOCINATIO*

Vitruvius himself is concerned with the arcane nature of architectural terms, which are neither intelligible by themselves nor in common use in his time. He sets out to provide short explanations of these terms in order to make them more intelligible to his readers (5.Pref.2). Thus, at the beginning of his first book, Vitruvius explains "*fabrica est continuata ac trita usus meditatio, qua manibus perficitur e materia cuiuscumque generis opus est ad propositum deformationis. Ratiocinatio autem est quae res fabricatas sollertia, ratione proportionis demonstrare atque explicare potest*." (1.1.1) Morgan translates this passage as "practice is the continuous and regular exercise of employment, where manual work is done with any necessary material according to the design of a drawing. Theory, on the other hand, is the ability to demonstrate and explain the production of dexterity on the principles of proportion" (1.1.1).[8] Based on Vitruvius's definitions, *fabrica* and *ratiocinatio* are usually translated as 'practice and theory'[9], or 'craft and reasoning,'[10] focusing on the distinction between practical and intellectual sources of the architect's knowledge. Exceptionally, Granger (1931) translates them as 'craftsmanship and technology' focusing on *fabrica* and *ratiocinatio* as the sources of architect's service rather than architect's knowledge.[11] Whether they are the sources of the architect's knowledge or their service, the translators' word choices illustrate the doctrine of duality between the Vitruvian pair. However, the confusion around some of the Latin terms, including *meditatio*, *propositum deformationis*, *fabricates sollertia*, and *ratione proportionis*, begs for reconsideration of this doctrine. What is the role of *meditatio* in manual work? What defines *propositum deformationis* for *fabrica*? How does *ratiocinatio* take into account skill (*sollertia*) and calculation (*ratione proportionis*)? Answering these questions requires a close reading of Vitruvius's definition of these terms. However, before doing so, it is crucial to study the etymology of *fabrica* and *ratiocinatio* to understand the way Vitruvius modified these terms and extended their use into architecture. The next two parts will offer a comparative study of the origins of *fabrica* and *ratiocinatio* and their definitions by Vitruvius.

1.1. *FABRICA* AS AN EXTENSION OF *TECHNĒ*

In modern English, we do not have a word that corresponds to Vitruvius's concept of *fabrica*. We have the word fabrication, whose etymology can be traced back to *fabrica*, implying the process of execution with an industrial connotation. It is more of a mechanical process. On the other hand, the Latin term *fabrica* is originated within a community of craftsmen and artisans. As a noun, *fabrica* derives from the word *faber*, which means a craftsman or an artisan who works in hard materials (Vaan 2008, 197). *Fabricāre/i*, as a verb, conveys the activity that is done by these craftsmen and artisans, i.e., "to fashion, to build, or to devise" (Vaan 2008, 197). It also implicitly conveys performing these activities skillfully because the adverb *fabre*, a derivative of *faber*, means "skillfully" (Vaan 2008, 197). Therefore, *fabrica* as a noun form of the verb '*fabricāre*' conveys the action or the process of making, building, or constructing skillfully. Furthermore, *fabrica* is semantically related to *technē* in Greek. *Technē* (skill) is etymologically linked to Proto-Indo-Europan root *tek-s-*, from which the Latin verb *texere* (to weave, to construct)

Figure 2: Image of a Greek *tektōn* (builder) carving the flutes of a column depicted on a bowl. (Boston Museum of Fine Arts)

is derived (Vaan 2008, 619). The English word textile, which is a synonym of fabric, derives from *texere*. Other Latin words related to textile, including *textilis* (woven, plaited), *textor* (weaver), *textūra* (weaving, structure) and *tēla* (cloth on a loom, spider's web), also derives from verb *textere* (Vaan 2008, 619). Understanding the relationship between *fabrica* and *technē* is important because it etymologically and semantically links the Vitruvian concept back to the architect. *Technē* is the root of the Greek word *tektōn,* which means artisan, craftsman, or builder, who works in hard materials. Thus, *fabrica* defines the activity of a *tektōn*.

In Greek, the word *architekton* is the combined form of *tektōn* and *archi-*, which means chief or head. Hence architect literally means chief or head builder (Barbaro 1567, 6; Parcell 2012, 25). The etymology of *architekton* suggests a shift in the architect's status from a builder who exercises manual work to a chief builder who manages not only the project but also builders.[12] Plato illustrates this status shift of the architect in his classification of knowledge. He uses kings and architects to exemplify *epitaktikē*, which is commanding knowledge classified under *gnostikē* (theoretical knowledge) rather than *praktikē* (practical knowledge) that would belong to builders (Pont, 2005). Plato sees the master-builder above the other builders. Stephen Parcell cites from Plato's conversation in the *Statesman*:

> Now consider a master builder. No master builder is a manual worker – he directs the work of others… He provides the knowledge but not the manual labor … so he might fairly be said to possess one of the theoretical forms of science … The master builder must give the appropriate directions to each of the workmen and see that they complete the work assigned. (Parcell 2012, 31)

This status change from *tektōn*, who exercises only the craft of building, to *architekton*, who exercises the thought and commands the builders, also appears in Vitruvius's *De Architectura*. Rowland argues that Vitruvius's agenda with writing a body of architecture dedicated to Emperor Augustus is "a bold attempt to transform architecture from a manual craft into one of the liberal arts" (2014, 288). For Greeks, *technē* consists of knowledge and procedure of making. Pollitt highlights that "the Greeks felt that art at all times involved *technē*, a combination of knowledge and orderly procedure organized for the purpose of producing a specific result." (1974, 22). For Vitruvius, architecture is a combination of both *technē* and the science of multiple disciplines. He sees architecture as a systematic art governed by science and principles. He concludes the introduction of his first book by promising that "in the following books I have disclosed all the principles of the art (*omnes disciplinae rationes*)" (1.Pref.3). To perform these principles of architecture, according to Vitruvius, the architect should have the knowledge of other disciplines, including writing, drawing, geometry, history, philosophy, music, medicine, law, and astronomy (1.1.3). On the other hand, a craftsman acquires local knowledge of a craft through his training as an apprentice in his family. An architect differs from a craftsman because he receives universal knowledge of these disciplines in addition to the knowledge of building (1.1.15).

Based on his aim of marrying architecture with the liberal arts, we can assume that Vitruvius does not offer *fabrica* as simply practice or manual activity but as practice supported by intellectual activity. For him, what differentiates the architect is his intellectual activity. Vitruvius writes:

> In fact, all kinds of men, and not merely architects, can recognize a good piece of work, but between layman and the latter there is this difference, that the layman cannot tell what it is to be like without seeing it finished, whereas the architect, as soon as he has formed conception, and before he begins the work, has a definite idea of beauty (*venustate*), the convenience (*usu*) and the propriety (*decore*) that will distinguish it. (6.8.10)

Considering Vitruvius's emphasis on the intellect, his use of *meditatio* in the definition of *fabrica* becomes a crucial question. In his definition of *fabrica*, he uses *meditatio*, which is a key term to understand mental activity woven into practice. However, some scholars either overlook *meditatio* or manipulate Vitruvius's words to enhance the duality between *fabrica* and *ratiocinatio*. Watzinger argues that *meditatio* "just like Greek μελέτη *(melétē)* designates the purely practical exercise and experience" (Watzinger 1909, 203). This position puts *fabrica* in opposition to *ratiocinatio*, which is purely theoretical. However, *meditatio* is derived from *meditos*, which belongs to *medeor*, meaning "to be a judge, to give a judgement." Hence, Vaan argues, *meditate/o* means "to judge constantly, contemplate" (2008, 365). In contrast to Watzinger, who refuses the intellectual capacity of *meditatio*, Perrault accepts *meditatio* as contemplation and, in fact, uses *meditatio* to describe how the theoretical knowledge is gained, rather than practical knowledge as Vitruvius originally wrote (Perrault 1692, 24).

Vitruvius's use of *meditatio* to describe *fabrica* is not random nor unintentional. *Meditatio* means contemplation (of an action) or the action of devising, planning, thinking out. In Barbaro's interpretation of *fabrica*, the word *meditatio* plays a key role. According to Barbaro, *meditatio* brings *fabrica* closer to *ratiocinatio*. He translates *fabrica* as "continuous and exercised thought (*meditatio*) about the use, . . ."[13] (Barbaro 1567, 8). Gwilt emphasizes the intellectual role of meditatio in his translation. He translates, "[p]ractice is the frequent

and continued contemplation of the mode of executing any given work, or of the mere operation of the hands, for the conversion of the material in the best and readiest way" (Gwilt 1826, 3). Unlike the common interpretations of the relationship between *fabrica* and *ratiocinatio*, Vitruvius does not prioritize thought over manual work. *Meditatio* in *fabrica* implies that thought as reckoning and computing was employed before and during the work in addition to thought as reflection carried out over the completed work. He defines *fabrica* and *ratiocinatio* as interdependent through the work of the architect.

1.2. *RATIOCINATIO* AS THE EXTENSION OF RHETORIC

Similar to *fabrica*, *ratiocinatio* is a term originated outside of architecture. Vitruvius borrows it from rhetoric and redefines it within the framework of his architectural theory. Rhetoric, in fact, had a significant influence on Vitruvian theory. In his analysis of *De Architectura*, Callebat asserts that the role of rhetoric in Vitruvius's treatise is more than a literary system of writing. "It is also, and more deeply—in a close encounter with architecture—that of an agent of conceptualization and theorization"[14] (1994, 34). Scholars have pointed out the similarities between Vitruvius's description of an architect's education and Cicero's definition of an orator's education (Romana 1987; Masterson 2004; McCoy 2017).[15] Moreover, besides *ratiocinatio*, Vitruvius borrows several other rhetoric concepts, including *ordinatio*, *distributio*, and *decor*. However, Vitruvius does not directly use them but adapts them into architecture so that he intersects craft and liberal arts. Similar to his redefinition of *fabrica* as the combination of manual and intellectual work as an extension of *technē*, he applies the same strategy to *ratiocinatio* to extend its use into architecture. Perrault's translation of *ratiocinatio* as *la theorie* in 1673 becomes the prevalent translation among Vitruvian scholars. However, as McEwen points out, Perrault's word choice is misleading because the Latin term *ratiocinatio* does not have a Greek equivalent, and the Greek *theoria* has much to do with observation and seeing (McEwen 2004, 6-7). *Ratiocinatio* derives from the Latin root *ratio* meaning 'calculation, account, reason' (McEwen 2004, 7). In Greek, *ratio* corresponds to *logos* meaning 'calculation, reason' and 'speech, word.' It comes from PIE root *leg-* meaning to collect, or to gather. Derivatives of *leg-* also mean to speak and to gather words in a speech (McEwen 2003, 60). The etymology of *logos* in Greek shows the rhetorical roots of *ratiocinatio*.

Scholars emphasize the rhetorical role of *ratiocinatio* as argumentation. Watzinger draws attention to Cicero's view on the eloquence of an architect. When Cicero writes about the famous Greek architect, Philo, who built an arsenal in Athens, he compares the architect to an orator. He claims the architect's eloquence does not come from the art of the architect, but from that of the orator. Thus, Watzinger argues that the ability to talk about the principles that governed his work was particularly significant for the ancient architects (Watzinger 1909). Moreover, Barbaro (1567) and Frezouls (1985) see the architect's prominent characteristic as being able to reflect on works. For Barbaro, the ability to judge other works is the differentiation quality (*differentia specifica)* of an architect. *Ratiocinatio* as *discorso* (discourse[16]) enhances the ability of judgment (Barbaro 1567). Under the influence of *ratiocinatio*'s rhetorical role, these scholars argue that *fabrica* comes first, before *ratiocinatio*.

Focusing on its rhetorical role, it is claimed that *ratiocinatio* produces knowledge through criticizing and reflecting on work. The interpretation of *ratiocinatio* as the intellectual reflection on the fabricated work causes a gap in the theory where "there is no ratiocinatio without a prior *opus*, there is no pure theoretical reflection, but an analysis of the practice"[17] (Frezouls 1989, 41). Frezouls argues that an architect can still build without theory, but there is no building to talk about without practice. He sees *fabrica* synonymous with *opus* (work), and *ratiocinatio* as the reflection or explanation of the work (Frezouls 1989, 41). His interpretation reduces not only *fabrica* to a work but also *ratiocinatio* to a discussion. However, according to Vitruvius, there is no gap between *fabrica* and *ratiocinatio*; on the contrary, they are inseparable (Granger 1925, 68). Both *fabrica* and *ratiocinatio* are required to acquire proper knowledge of architecture. Vitruvius wrote, "architects who aimed at acquiring manual skill without scholarship have never been able to reach a position of authority to correspond to their pains, while those who relied on only upon theories and scholarship were obviously hunting the shadow, not the substance" (1.1.2). He compares the architect who acquired the knowledge of both *fabrica* and *ratiocinatio* to a fully armed man ready to build his work speedily and defend it with authority. However, it is not Vitruvius's only focus. Vitruvius extends the use of *ratiocinatio* from rhetoric into practice. Rather than a discussion, Perrault sees *ratiocinatio* as reasoning that directs the practice (1973, 1).[18] Similarly, Galliani argues *ratiocinatio* ensures the best possible layout of future work (Galiani 1758, xvi).[19]

In Vitruvian theory, ratiocinatio is active not only after the work is complete to criticize it, but also during the execution to ensure the coherency in the work. As Indra McEwen points out, for Vitruvius, *ratio*, the root of *ratiocinatio*, provides the work with coherency. Any work produced with reason or rationale would

provide authority to its architects (McEwen 2003). Thus, *ratiocinatio* is not only a rhetorical act, but it is also a design act that guarantees the success of the work. As Vitruvius explains in his fifth principle: "Propriety (*decor*) is perfection of style which comes when a work is authoritatively (*cum auctoritate*) constructed and approved principles" (1.2.5).[20] Vitruvius emphasizes the role of *ratiocinatio* as the source of authority. It provides authority to a work by ensuring the work is carried out through principles supported by the knowledge of other sciences (1.1.2). It also defends the authority of the work by demonstrating and explaining these principles. Vitruvius extends the use of *ratiocinatio* outside of its rhetorical notion. He defines *ratiocinatio* as an act that provides both persuasion and coherence in work. Therefore, in Vitruvian theory, *fabrica* and *ratiocinatio* perform simultaneously in architecture, not only during the design but also after the design is carried out. However, such a statement raises further questions: how do *fabrica* and *ratiocinatio* work together? How do they interact in architecture?

2. *FABRICA* AND *RATIOCINATIO* INTERWOVEN IN DRAWING

Drawing is a key concept in Vitruvian theory. In his essay "*Vitruve et le Dessin d'Architecture*," Frezouls emphasizes the significance of drawing for Vitruvius by pointing out that ". . . drawing is present at every level of Vitruvian theory,"[21] (1985, 220) including *fabrica* and *ratiocinatio* as well. He asserts that drawing is the contact point between the architect's mental and manual activity, referring to *ratiocinatio* and *fabrica*, respectively (1985, 228). According to Frezouls, drawing is a mode of realization that belongs to the preparation phase. It is evoked by calculation and used as a base for execution (Frezouls, 213-214). Considering drawing as only a mode of realization supports Frezouls' argument; however, for Vitruvius, drawing is not only a tool but also a skillful and systematic activity. Based on Vitruvius's definition of drawing both as a skill and knowledge, this study claims that *fabrica* and *ratiocinatio* interact with each other on multiple levels in work. This part analyzes the role of drawing in *De Architectura* to understand how Vitruvius set *fabrica* and *ratiocinatio* in interaction. Firstly, it will study drawing as a medium that serves both *fabrica* and *ratiocinatio*, and then, analyze it as the activity the architect performs to reveal the complex relationship between the two concepts.

In the first chapter of his first book, Vitruvius defines drawing as both a skill and knowledge. Vitruvius wrote that an architect should be "skillful with pencil" (*peritus graphidos*) (1.1.3). Later in the same chapter, he added that an architect could not be a painter as skillful as Apelles; he must not be "unskillful in drawing" (*graphidos non inherits*) (1.1.13). After emphasizing drawing as a skillful activity, Vitruvius lists drawing, in addition to other liberal arts, as a science (*graphidos scientiam*) that an architect should be educated in. He says the architect "must have the knowledge of drawing so that he can readily make sketches to show the appearance of the work which he proposes" (1.1.4). Besides being a skill carried out by hand, drawing is also a systematic knowledge supported by other sciences and theories. Kanera argues that Vitruvius's introduction of drawing along with the other sciences in his education program for the architects caused a change in Renaissance authors' view of drawing in relation to sciences. In the middle ages, science is privileged over drawings, which were seen as a simple craft. After Vitruvius's manuscripts were made available to scholars, Renaissance authors and architects accepted Vitruvius's view as an authoritative proof of the high value of drawing (Kanerva 2006, 175-76). As drawing becomes fundamental to architecture, Vitruvius's double formulation of drawing both as a skill and as knowledge also enhances his goal of elevating architecture's status to the level of a liberal art. It is no longer simply manual activity of craftsmen, but an activity of architects evoked by both *fabrica* and *ratiocinatio*. Therefore, drawing is more than a single contact point between manual and mental activity, as Frezouls argued. It must be a result of a tangled relationship between *fabrica* and *ratiocinatio*.

For Vitruvius, drawing, as a mode of realization, serves not only for *fabrica* to show the form given to the matter but also for *ratiocinatio* to demonstrate and explain the work. Even though only a few samples of architectural drawings from the ancient Greek and early Roman period survived today, it is clear that ancient architects often used drawings to convey their ideas to builders and commissioners.[22] While they also used textual and verbal descriptions of their projects, they referred to drawings whenever the project got too complex to describe through words (Corso 2016; Gros 1996). For example, explaining a simple house layout through the verbal or textual medium was easy, but a complex project like a bathhouse required visual representation (Corso 2016, 24). Vitruvius writes that architects use drawing "to show the appearance of the work which he proposes" (1.1.4). Architects transfer their *idea* onto drawing to show how builders ought to construct a wall, or carve a column, or paint decorations. Besides using drawing as a preparatory medium for the execution of a work, ancient architects, including Vitruvius, also used drawings in addition to their text to illustrate their comments. In *De Architectura*, Vitruvius offers ten drawings for which he uses the words *forma*, *schema*, *diagramma*, or *exemplar*.[23] He mentions these drawings or refers back to them

¶ Ma le altre cõ equale modo diſpoſite: acioche ſingula ſingulis: ſeu ciaſcuna a ciaſcune a le medie tegule ſe reſpondano: In queſta parte Vitruuio non ſolum oſtende el collocare de quiſti capi leonini ſoto le medie tegule per la integritate ſua: ma etiam inſigna il modo de coprire queſte ſorte de quale generatione de tegule: aut imbrice: o di laſtre al modo de le coperture de li Cõmenſi & per la Germania & la Galia Tranſalpina ſi uſa: aut como antiquitus: & etiam in hodiernum diem in molti loci: ſi in la Italia quanto etiam altroue ſono uſati de uaria opera coſtilie: uel figulina uitrata al modo de germania ut diximus & altri loci. ¶ Ma queſte che ſarano contra le columne Il texto da ſe mi pare claramente ſi explica: & tanto piu quanto la figura te indica queſte grondatione ſeu ſtylicidante collocatione o ſiano uerſo il Tympano procurrente uel altro modo ſi pono collocare. E coſa ſcienda che queſte generatione de colũne Ionice ſiano ſtate

Ma le altre cõ equale modo diſpoſite: acio che ciaſcuna a ciaſcune me die tegule ſe reſpondano. Ma queſte che ſarano cõtra le colũne ſiano perforate al canale: quale excipe da le tegule laqua cœleſte. Ma li capi mediani ſiano ſolidi acio che la forza del aqua: quale cade per le tegule in lo canale non ſe expanda di fora p li intercolumnii: ne anche perfunda le perſone che paſſano: Ma quelle che ſono cõtra le colũne ſi uedano emittere da la bocha le uomentie de il ructo de le aque: De le cæde Ionice quanto aptiſſimamẽte ho potuto le loro diſpoſitione in queſto uolumine ho deſcripto: Ma de le Doriche & Corynthie: qual ſiano le ſue proportione in lo ſequente libro explicaro.

da li antiqui diuiſe in uarie ſymmetrie le loro ſtriature: Alcuni hano diuiſo il ſcapo in lo modo che haueremo de le Thuſcanice columne: In lo inſequente libro quarto: Alcuni perho uolendo che queſte Ionice: & coſi epſe Thuſcanice che ſono mancho canate de ſtriature de tute le altre ſiando perho diuiſe niſi per fare uigintiquatro ſtrie: chi ha cõpartito li loro ſcapi in parte ſeptanta due: dando due parte in lo cauo de la ſtria: & una a lo ſtriglo exteriore: Alcuni altri hano diſtincti li p̃dicti ſcapi: In parte nona ginta ſex faciendo etiam il dicto ſtriglo ſia niſi una parte: & tre ſiano tribuite a li cani di epſe ſtrie.

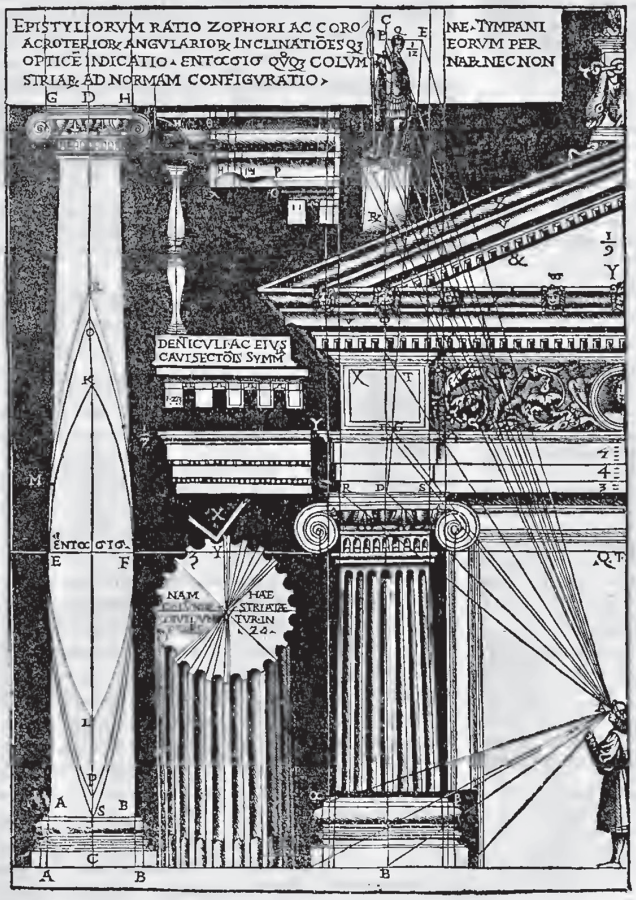

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Figure 3: Entasis diagrams from Cesarino's Italian Translation in 1521. (Cesarino 1521, LX)

multiple times throughout the ten books. Gros argues that despite Vitruvius's goal of producing a textual body of architectural theory, "the figure takes over from the text only in cases very punctual when Vitruvius is aware of having reached the limits of his formulation and/or conceptualization"[24] (Gros 2006 [1996], 328).

In addition to viewing drawing as a visual representation, Vitruvius also conceptualizes it as a procedural action performed by architects' hands and minds. One of the ten drawings promised by Vitruvius, a diagram of winds can be reconstructed by following Vitruvius's description of the drawing. Vitruvius provides a procedural description of how to construct the diagram. He writes:

> Let A be the center of a plane surface, and B the point to which the shadow of the gnomon reaches in the morning. Taking A as the center, open the compass to the point B, which marks the shadow, and describes a circle. Put the gnomon back where it was before and wait for shadow to lessen and grow again until in the afternoon it is equal to its length in the morning, touching the circumference at the point C. Then from point B and C describe with he compasses two arcs intersecting at D. Next draw a line from point of intersection D through the center of circle to circumference and call if E F. This line will show where the south and north lie. (1.6.12)

Although this is the only diagram in his treatise that can be completely reconstructed by following his procedural descriptions, it clearly shows that Vitruvius considers drawing as an activity that the mind and hands perform together. The mind follows the systematic information and the hands trace lines on a surface. He continues by saying, "then find with the compasses a sixteenth part of the entire circumference; then center the compasses on the point E where the line to the south touches the circumference and set off the points G and H to the right and left of E" (1.6.13). He describes drawing as an activity that produces a geometric pattern and as a method to calculate and measure the geometry. Mind calculates through making and drawing. The motion between mind and hands becomes cyclic.

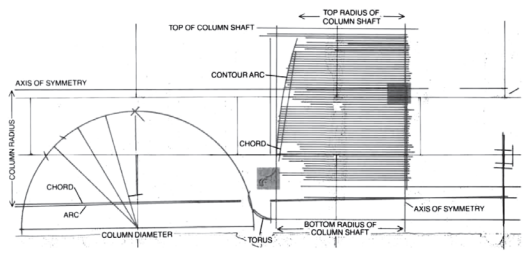

Figure 4: Three overlapping drawings showing the shape of a column and two vertical cross-sections of a column are traced over a photograph from Temple of Apollo by Haselberger. The vertical cross-section shows the *entasis* of the column. (Haselberger 1985, 130)

Vitruvius himself also explains that when his ideas or the geometry gets too complex that he cannot afford to describe them through texts, and he resorts to drawing. According to him, knowledge of geometry helps architects draw these complex projects by teaching them how to use the rule and compass. He writes, "[g]eometry, also, is of much assistance in architecture, and in particular it teaches us the use of the rule and compass by which especially we acquire readiness in making plans for buildings in their grounds, and rightly apply the square, the level, and the plummet" (1.1.4). He added that the geometrical theories and methods assist architects to resolve the difficult question involving symmetry (*difficilesque symmetriarum quaestiones*), which is one of his six principles. By geometry, Vitruvius does not mean a visual depiction of a building, but a system of proportion or a formulation of relations between its elements. Vitruvian man, Vitruvius's textual formulation of the ideal body (3.1.2), exemplifies his understanding of geometry. As McEwen points out Vitruvian man is neither a depiction nor a product of geometry, rather, it is the source of geometry (2003, 157). Considering Vitruvius's statement about geometry's role, it is not surprising that he used three out of ten drawings in his third book in which he describes the symmetry of temples. One of these drawings presents *entasis*, a slight enlargement made in the middle of a column to fix the optic deformation on straight shafts searching for beauty. Vitruvius promises a figure and calculations of *entasis* at the end of the third book (3.3.13); however, they are not found in any of the manuscripts. Early editors and translators of *De Architectura* offered a figure of entasis based on archeological findings and measurements (figure 3a-b). In 1989, archeologist Haselberger found incised drawings, one of which shows the calculation of a column's entasis on the walls of the Hellenistic Temple of Apollo in Didyma (figure 4) (Haselberger 1985). Even though it is not sure whether this drawing and calculation correspond to what Vitruvius provided in his manuscript, this discovery proves that specific calculations described in drawings are used by Hellenistic architects during the construction phase.

While the two entasis drawings, one is described in *De Architecture* and the other one is drawn in the Temple of Apollo, show the link between theory and practice, another tracing depicting the temple's layout reveals more important information on the use of drawing as a design medium among ancient architects. This tracing of the layout found on the base of the Temple of Apollo shows alterations in the geometry and proportions of the layout in time. Therefore, this drawing is both a construction-drawing and a design-drawing that is open for changes even

during the construction phase (Jones 2003). Design usually precedes construction, yet in this particular example, design continues during the construction. The altered traces on the stone surface imply that drawing becomes a medium upon which the changes in design are reflected. Changes also impact the construction in terms of the form, dimensions, and position of elements. Vitruvius's theory also highlights the significant role of drawing in design. Vitruvius mentions that plan drawing (*ichnographia*), elevation drawing (*orthographia*), and perspective (*scaenographia*) as the expressions (*ideai* in Greek) of his second principle of architecture, *dispositio*, which "includes the putting of things in their proper places and the elegance of effect which is due to adjustments appropriate to the character of the work" (1.2.2). It is not unusual that Vitruvius defines these three forms of drawing as an activity. He writes:

> A ground plan is made by the successive use of compasses and rule, through which we get outlines for plane surfaces of buildings. An elevation is a picture of the front of a building, set upright and properly drawn in the proportions of the contemplated work. Perspective is the method of sketching a front with the sides withdrawing into the background, the lines all meeting in the center of a circle. (1.2.2)

Vitruvius adds that these drawings come from reflection (*cogitatione*) and invention (*inventione*).

> Reflection is careful and laborious thought, and watchful attention directed to the agreeable effect of one's plan. Invention, on the other hand, is the solving of intricate problems and the discovery of new principles by means of brilliancy and versatility. (1.2.2)

Vitruvius defines reflection and invention as intellectual activities solving the problems of architecture. Furthermore, these intellectual activities are carried out though practice. In his third book, Vitruvius praises Hermogenes for developing a new principle of the pseudo-dipteral octastyle temple. Hermogenes's invention saves expense and labor and provides a much wider space for walking around the cella and sheltering during the rain. He achieves these by "dispersing with the inner rows of thirty-eight columns which belonged to the symmetry of the dipteral temple" (3.3.8). He changed the layout by removing some columns and rearranging the proportion that would "preserve the dignity of the whole work" (3.3.8). While developing this new layout, according to Vitruvius, Hermogenes takes into account not only quantitative calculations like geometry for the proportion, arithmetic for calculating the expenses but also qualitative reckoning like the use of space, dignity, and beauty of the whole work. While solving such complex issues, Hermogenes relies on both ratiocinatio and fabrica to produce a coherent work through calculation and execution. Hermogenes's novel work shows that reflection and invention are not only about the intellectual activity but also about making, visualizing and crafting. There is no gap between *fabric* and *ratiocinatio*. For example, drawing is both a manual and mental exercise, where the architect learns and advances their thought by practicing, and vice versa.

CONCLUSION

The confusion around the relationship between *fabrica* and *ratiocinatio* in Vitruvian theory echoes in whether *De Architectura* is a practical manual on know-how of architectural profession or a theoretical text on knowledge of architectural discipline (Frezouls 1989, Jones 2000, Fitzpatrick 2017). Is *De Architectura* a product of practice or of theory? Considering the historical influence of Vitruvian thoughts in both architectural practice and architectural theory, it is clear that no such distinction can be made for *De Architectura*. As Frezouls claims, Vitruvius had the goal of producing a complete body of work dedicated to a collection of directions for building and also principles for the art of building. He writes:

> The double formulation according to which the work is presented both as a collection of *praescriptiones terminatae* and as a logical statement of architecture—*omnes disciplinae rationes*—suggests well for the treaty two distinct perspectives: a practical guide, allowing to construct all kinds of buildings but also that of a work giving access—overview—to the logical sequences which make architecture not only know-how but knowledge.[25] (Frezouls 1989, 40)

Considering the double purpose of *De Architectura*, this essay examined the false duality between the two significant components of architect's knowledge, *fabrica* and *ratiocinatio* in Vitruvian theory. Rather than focusing on the prevailing opposition between the Vitruvian pair, this inquiry sought to reveal the interactions between fabrica and ratiocinatio.

The etymology and early use of both *fabrica* and *ratiocinatio* confirms an opposition between these two terms. *Fabrica* as a craft term implies the work of a craftsman, an artisan or a builder. It is concerned simply with the practice or/and knowledge of that practice. On the other hand, *ratiocinatio* is a rhetorical term concerning with argumentation, reasoning and structuring of a speech or thought. In Vitruvian theory, we see that the use of both concepts is extended into architecture. Vitruvius sees architecture as an art combining both manual and intellectual production. For example, drawing is not simply a representation produced by physically drawing with a pen on paper. As much as it is a physical activity, it is also an intellectual activity (*meditatio*)—an exercise of thought through motion. Vitruvius shifts the

meaning of *fabrica* from mere craft to both manual and intellectual act by emphasizing *meditatio* in its definition. Likewise, thought is not merely a mental activity, but a contemplation on/through practice taking into account both skill and calculation (*sollertia et ratione proportionis).* Drawing clearly illustrates the interaction between *fabrica* and *ratiocinatio*. Drawing is produced and used by both *fabrica* and *ratiocinatio*. They use drawing to demonstrate and explain the work whether it is in-situ showing the details of construction, or in text illustrating the argument. As Vitruvius implies, drawing is a thought exercise carried out through manual activity of hands. There is no gap between thought and activity, i.e., both fabrica and ratiocinatio make use of drawing and operates through mind and hands simultaneously.

This inquiry sees Vitruvian theory as a fabric of relations in which both *fabrica* and *ratiocinatio* are in an interwoven relationship. While the metaphor of weaving illustrates the relationship between *fabrica* and *ratiocinatio*, this inquiry aims at extending weaving beyond a metaphor to create a material link between fabric and *fabrica,* and loom and *ratiocinatio*. The act of weaving suggests a direct relationship between matter and thought, making and thinking. This study lays the groundwork for future research on the relationship between Vitruvius's theoretical frameworks. Within this fabric of Vitruvian theory, a significant question remains to be answered. How do *fabrica* and *ratiocinatio* interact with Vitruvius's other two theoretical frameworks: the principles of design and the triadic structure of architecture?

ENDNOTES

1 There are several English translations of Vitruvius's *De Architectura* including Gwilt (1826), Morgan (1914), Granger (1931), Rowland and Howe (1999), Smith (2003) and Schofield (2009). In this essay, I use Morgan's 1960 edition of his 1914 translation.

2 Berardo Galiani (1758, xv).

3 As Branko Mitrović (2019, xi-xxxviii) cites from Barbaro's commentary on Aristotle's *Rhetoric* (1542a).

4 F. I. G. Rawlins (1950).

5 Frezouls warn us against the assimilation of Vitruvian couple to *technē* and *epistēmē*, however, he fails to avoid from comparing them to Aristotelian *ergon* and *logos*. Frezouls (1989, 41) writes *"Sans reprendre une discussion engagée ici-même, observons la prudence qu'elle nous conseillait: il vaut mieux éviter d'assimiler ce couple à l'opposition grecque classique entre technè et epistémè. Toutefois on ne peut manquer de rapprocher le binôme de celui, encore plus banal, que forment ergon et logos, avec l'avantage de trouver ici pour logos un glissement sémantique--homologue de celui qu'on observe pour ratiocinatio--du sens de parole au sens plus dense de "discours, raisonnement, raison"."*

6 Graham Pont (2005) links Vitruvius' division of architectural knowledge into practice and theory to Plato's distinction between the science of knowledge (*praktikē*) and the science of mere knowing (*gnostikē*).

7 Weaving played a central role in Greek *oikos* (household). Looms were the central artifact of ancient Greek houses. Thanks to its material presence in Greeks' daily lives, fabric and weaving emerged as a rich metaphor in their culture, especially in their art. For more on the metaphor of fabric and weaving in Greek and Roman myth and society, see *The Craft of Zeus* by John Scheid and Jesper Svenbro (1996).

8 Translation by Morris Hicky Morgan (1960). The Latin text is added in parenthesis by the author.

9 Claude Perrault (1673) uses '*la pratique et la théoria*' for the first time in his French translation. Berardo Galiani (1758) translated them as '*la pratica e la theorica*' in Italian. 'Practice and theory' become the common word choice among English translators: Joseph Gwilt (1826), Morris Hickey Morgan (1914), Ingrid Rowland and Thomas Howe (1999), Richard Schofield (2009).

10 Thomas Gordon Smith (2003).

11 Frank Granger suggests that fabrica and ratiocinatio are the source of architect's service rather than their common interpretation as the source of architect's knowledge. Granger grounds his interpretation on the mispunctuation in the first two sentences of the first book. He claims that the first sentence ends with *perficiuntur* and the second sentence starts with *opera* and reads as "*Opera ea nascitur et fabrica and ratiocinatione."* Hence *opera* defines 'personal service' of an architect and it "consists in craftsmanship and technology." (Granger 1931, 6-7).

12 J.J. Coulton (1977) gives a detailed analysis of the relationship between architect, patron and project in the first chapter of his book *Ancient Greek Architects at Work*. Moreover, in his article "The Fall of the Tektōn and The Rise of the Architect", Jonas Holst gives a thorough analysis of changing values of *tektōn* as a craftsman throughout the antiquity.

13 Translated by the author. Barbaro (1567, 8) wrote, *"Fabrica è continuo, & essercitato pensiero dell'uso, che di qualunque materia, che per dar forma all'opera proposta si richiede, con le mani si compie."*

14 Translated by the author from French. Callabat (1994, 34) wrote, *"La fonction de la rhétorique, dans le De architectura, n'est pas cependant celle seulement d'un système littéraire de l'écrit, d'un moyen efficace de communication ou d'une valorisation culturelle. Elle est aussi, et plus profondément--dans une rencontre étroite avec l'architecture--celle d'un agent de conceptualisation et de théorisation."*

15 Elisa Romana (1987), Masterson (2004, 393), Harris-McCoy (2017, 111).

16 Translated by Kim Williams (2019).

17 Translated by the author. Frezouls (1989, 41) wrote: *"… il n'y pas de ratiocinatio sans opus préalable, il n'y pas de réflexion théorique pure, mais une analyse de la pratique."*

18 In his translation Perrault (1673, 2) notes that he doesn't prefer to translate ratiocinatio as raisonnement (reasoning) because it is too general, and fabrica as fabrique (fabricated) because it is not French.

19 Translated by the author. Galiani (1758, xvi) wrote, *"La Teorica consiste nel sapire concepire la miglior distribuzione di une dato spazio, per formarvi co'dati materiali tutti i maggiori comodi, che si possono secondo la mente del padrone, e secondo la somma, ch'egli vi vuole impiagare."*

20 The original Latin term '*decor*' as used by Vitruvius is given in the parenthesis by the author.

21 Translated by the author. Frezouls (1985, 220) writes, *"Quoi qu'il en soit de ce point particulier, on doit convenir que le dessin est présent à tous les niveaux de la réflexion générale de Vitruve, et donc, certainement, pour une large part, de ses sources."*

22 Corso (2016) gives a thorough study of drawing in ancient Greece and Roman Empire. He studies drawing in Greek and Roman architecture through archeological and textual sources. More can be found in Antonio Corso, 2016. *Drawings in Greek and Roman Architecture*. Oxford: Archaeopress Publishing.

23 In the first book, Vitruvius mentions two drawings: one showing the directions of winds and the other one showing the networks of the roads of a city. In the third book, he mentions a drawing concerning *entasis* and a drawing and a formulation of an ionic column›s volutes. In addition to them, he offers a drawing of altars in book four, a diagram explaining *echeia* in book five, a drawing of chorbates in book eight, a schema of duplication of the squares, and a drawing showing the position of ladders with indications of the levels of steps in the book nine and finally a drawing of Archimedes's screw in the book ten.

24 Translated by the author. Gross (2006, 14) writes, *"Il apparaît ainsi que la figure ne prend le relais du texte que dans les cas très ponctuels où Vitruve a conscience d'avoir atteint les limites de sa formulation et/ou de sa conceptualization."*

25 Translated by the author. Frezouls (1989, 40) writes,*"La double formulation selon laquelle l'ouvrage est présenté à la fois comme un recueil de praescriptiones terminatae et comme un exposé logique de l'architecture--omnes disciplinae rationes--suggère bien pour le traité deux perspectives distinctes: celle d'un guide pratique, permettant de construire toute espèce de bâtiments mais aussi celle d'un ouvrage donnant accès--aperui--aux enchaînements logiques qui font de l'architecture non pas seulement un savoir-faire mais un savoir."*

REFERENCES

Barbaro, Daniel. 1567. *I Dieci Libri dell'Architettura di M. Vitruvio, Tradotti & Commentati*. Venetia : appresso Francesco de'Franceschi Senese et Giovanni Chrieger Alemano.

Callebat, Louis. 1994. "Rhétorique et architecture dans le «De Architectvra» de Vitruve," in *Le projet de Vitruve. Objet, Destinataires et Réception du De architectura Actes du Colloque International de Rome*. Rome: École Française de Rome:

Callebat, Louis. 2001. "Fabrica et Ratiocinatio dans le De Architectura". *Imaginaire et Modes de Construction du Savoir Antique dans les Textes Scientifiques et Techniques*. Perpignan: Presses Universitaires de Perpignan.

Cesarino, Cesare, Mauro Bene and Benedetto Giovio. 1521. *Di Lucio Vitruvio Pollione De Architectura Libri Dece Traducti de Latino in Vulgare Affigurati: Comentati: Et con Mirando Ordine Insigniti: Per il Quale Facilmente Portrai Trovare la Moltitudine de li Abstrus et Reconditi Vocabulia li Soi Loci et in Epsa Tabula con Summo Studio Expositi et Enucleati ad Immensa Utilitate de Ciascuno Studioso et Benivolo de Epsa Opera*. Milan: Gotardo da Ponte.

Corso, Antonio. 2016. *Drawings in Greek and Roman Architecture*. Oxford: Archaeopress Publishing.

Coulton, J. J. 1977. *Ancient Greek Architects at Work: Problems of Structure and Design*. Ithaca: Cornell University Press.

Fitzpatrick, Nichols Marden. 2017. *Author and Audience in Vitruvius's De Architectura*. Cambridge: Cambridge University Press.

Frezouls, Edmond. "Fondements Scientifiques, Armature Conceptuelle et Praxis Dans le De Architectura" in *Munus Non Ingratum: Proceeding of the International Symposium on Vitruvius's De Architectura and the Hellenistic and Republican Architecture*. Leiden: Stichting Bulletin Antieke Beschaving: 39-48.

Frezouls, Edmond. 1985. "Vitruve et le Dessin d'Architecture," in *Le Dessin d'Architecture dans les Sociétés Antiques, Actes du Colloque de Strasbourg.* Strasburg: Brill Archive

Galiani, Berardo. 1758. *L'architettura di M. Vitruvio Pollione: Colla Traduzione Italiana e Comento*. Napoli: Nella Stamperia Simoniana.

Gargano, Maurizio. 2006. *Forma e Materia: Ratiocinatio e Fabrica nell'Architettura dell'Età Moderna*. Rome: Officina.

Giocando, Fra Giovanni. 1511. *M. Vitruvius per Iocundum Solito Castigatior Factus, Cum Figuris et Tabula, ut Iam Legi et Intellegi Possit.* Venice: Giovanni de Tradino alias Tacuino.

Granger, Frank. 1925. "Vitruvius's Definition of Architecture." *The Classical Review* Vol. 39, 3/4: 67-69.

Granger, F. and Vitruvius. 1983. *Vitruvius on Architecture*. Cambridge, Mass: Harvard University Press. (original publication in 1931).

Gros, Pierre. 2006. "Les Illustrations du De Architectura de Vitruve: Histoire d'un Malentendu," in *Vitruve et la Tradition des Traités d'Architecture: Fabrica et Ratiocinatio*. Rome: l'École Française de Rome: 325-339.

Gwilt, J. and Vitruvius. 1826. *The Architecture of Marcus Vitruvius Pollio in Ten Books*. London: Priestley and Weale.

Halsenberger, Lothar. 1985. "The Construction Plans for the Temple of Apollo at Didyma." *Scientific American* Vol. 253, 6: 126-133.

Harris-McCoy, Daniel. 2017. "Making and Defending Claims to Authority in Vitruvius's De Architectura." In *Authority and Expertise in Ancient Scientific Culture*. Cambridge: Cambridge University Press. 107-128.

Holst, Jonas. 2017. "The Fall of the *Tektōn* and The Rise of the Architect: On the Greek Origins of Architectural Craftsmanship." *Architectural Histories*, 5 (1): 1–12.

Jolles, J. A. 1905. *Vitruvs Aesthetik*. Freiburg: Universitats-Buchdruckerei.

Jones, Mark Wilson. 2009. *Principles of Roman Architecture*. New Haven and London: Yale University Press.

Kanerva, Liisa. 2006. *Between Science and Drawings: Renaissance Architects on Vitruvius"s Educational Ideas.* Vaajakoski: Finnish Academy of Science and Letters.

McEwen, Indra Kagis. 2003*. Vitruvius: Writing the Body of Architecture.* Cambridge: MIT Press.

McEwen, Indra Kagis. 2004. "Vitruvius, or the Hidden Menance of Theory." *Auf Der Suche Nach Einer Theorie der Architektur* Band 12.

Mitrović, Branko. 2019. "Daniele Barbaro's Architectural Theory" in *Daniele Barbaro's Vitruvius of 1567*, ed. Kim Williams. Birkhäuser: xi-xxxviii.

Morgan, M. H. and Vitruvius. 1960. *Vitruvius: The Ten Books on Architecture*. New York: Dover Publications.

Parcell, Stephen. 2012. *Four Historical Definitions of Architecture*. Montreal: McGill-Queen's University Press.

Perrault, Claude. 1673. *Les Dix Livres d'Architecture de Vitruve, Corrigez et Traduits Nouvellement en François, avec des Notes & des Figures.* Paris: Chez Jean Baptiste Coignard.

Perrault, Claude. 1674. *Abregé des Dix Livres d'Architecture de Vitruve*. Paris: Chez Jean Baptiste Coignard.

Perrault, Claude. 1692. *An Abridgment of the Architecture of Vitruvius.* London: Abel Swall and Timothy Child.

Pollitt, J. J. 1974. *The Ancient View of Greek Art: Criticism, History, and Terminology*. New Haven and London: Yale University Press.

Pont, Graham. 2005. "The Education of Classical Architect from Plato to Vitruvius." *Nexus Network Journal* Vol. 7-1: 76-85.

Rawlins, F. I. G. 1950. "Episteme and Techne." *Philosophy and Phenomenology Research* Vol. 10, 3: 389-397.

Romano, E. 1987. *La capanna e il tempio: Vitruvio o dell'architettura.* Palermo: Palumbo.

Romano, Elisa. 2017. "Si qui voluerit Vitruvius on Architecture as 'the Art of the Possible'." *Knowledge, text and Practice in Ancient Technical Writing.* Cambridge: Cambridge University Press. 53-67.

Rowland, Ingrid D. 2005. "From Vitruvian Scholarship to Vitruvian Practice." *Memoirs of the Academy in Rome.* Rome: The American Academy in Rome. 14-40.

Rowland, I. D., Thomas N. Howe and Vitruvius. 1999. *Vitruvius Ten Books on Architecture*. Cambridge: Cambridge University Press.

Scheid, John and Jesper Svenbro. 1996. *The Craft of Zeus: Myths of Weaving and Fabric.* Trans. By Carol Volk. Cambridge, Mass. And London: Harvard University Press.

Schofield, R. and Vitruvius. 2009. *Vitruvius on Architecture*. Penguin Classics.

Smith, T. G. and Vitruvius. 2003. *Vitruvius on Architecture*. The Monacelli Press. Vaan, Michiel de. 2008. *Etymological Dictionary of Latin and the other Italic Languages*. Leiden, Boston: Brill.

Watzinger, Carl. 1909. "Vitruvstudien." *Rheinisches Museum für Philologie* Vol. 64: 202-223.

Williams, Kim. 2019. *Daniele Barbaro's Vitruvius of 1567*. Birkhäuser.